09/529004

WO 99/18171

PCT/HU98/00034

527 Rec'd PCT/PTO 06 APR 2000

Closed-loop Continuous Operating Pyrolysis System for Processing Rubber Waste

Field of the Invention

The invention relates to a continuous operating system for processing the crushed rubber waste, by the aid of which - considering the quantity of the fed rubber waste - environment protecting liquid hydrocarbon of approximately 40-45 weight percent as well as coke of 30-45 weight percent can be produced as end product suitable for further processing. The closed-loop, controlled respectively adjusted system according to the invention ensures more economical recycle considering the known solutions and its importance is increased by the fact that the flue-gas leaving the system contains components only in slight quantity harmful to the environment much less than the admissible limit value.

Nowadays the important technical tasks stay in the center as for processing of the wastes accumulating in the environment as for exploring the recycling possibilities.

Numerous efforts are known for recycling the rubber wastes - such as the rubber tires amounting to its considering quantity - however, most of them proved uneconomical, respectively unsuitable for the mass production.

Prior Art

There are known such kind of solutions for example, which tend to the regeneration of the vulcanized grinds in order to be re-milled and re-calendered (recycling). The mutual disadvantage of the mentioned solutions is the considerable energy demand. As an example, the HU-PS 157,607 patent specification describes a solution, wherein the regeneration is performed only in the surface layers by means of double-stage heating process in the presence of oxygen by solution of double bonds.

A further part of the known solutions tends to produce the production from the mechanically crushed rubber waste, e. g. AT-PS 339,797 as well as AT-PS 355,291, and AT-PS 368,446 as well as CH-PS 601,567 patent specifications disclose the solutions for preparing floor-coverings, coverings for sporting ground; while from DD-PS 252,945 and HU-PS 206,383 patent specifications a process can be known for pro-

ducing heat-insulating and noiseproof shaped figures. Furthermore, the use of the crushed rubber granule material at the road construction is also known, which is disclosed in DD-PS 121,744 patent specification. The advantage of these kind of solutions is in that the end product is made essentially from waste materials, and its disadvantage lays however in the fact that it does not represent considerable market demand.

In a further group of the utilization of the solutions, the rubber waste is used for recovering as fuel material. E. g. according to the DE-PS 2,131,519 the granules of the rubber waste are mixed with coal grains, then it will be molded and finally at the temperature of the 500-600 °C it will be briquetted. In the case of the solution described in CH-PS 615,215 the granules of the rubber waste are mixed with coal flours, and then it will be heat treated. According to the DE-PS 2,254,472 the rubber waste is also used for recovering as fuel material, wherein the crushed rubber tire is mixed with black oil. As a matter of course, these processes serve for the destruction (burning) of the rubber wastes.

Finally, the solutions have to be mentioned, wherein the aim is to reclaim the petroleum fractions, organic chemical raw materials used for the rubber production.

Such kind of process is disclosed by the Hungarian patent application No. 3374/84, the publication number of which is T/40.883, wherein the rubber waste is mixed with coal and/or charred coal, and after that in discontinuous operating carbonization chamber (advantageously metallurgy respectively in the appliances producing domestic gas) it will be carbonized. The advantage of the solution is in that the oil tar arising during the heat treatment burns on the particles of the coal or charred coal and increases their mass, while its disadvantage is the uneconomical discontinuous operation.

From the US-PS 4,202,613 can be known an apparatus respectively a process, wherein during continuous operation partial oxidation and pyrolysis takes place. The GB-PS 1,437,224 discloses a process similarly for continuous operation, wherein the partial gasification of the rubber chips takes place at the rate of air lower than the stoichiometric air demand, and as a result of the procession burnable gas and charred coal is regenated.

Summary of the Invention

The aim of the invention is to realize a complex system (appliance) developing the known solutions, wherein restoring of the petroleum fractions can be realized more economically than in the known solutions.

On the basis of the above-mentioned aim the invention relates to a pyrolysis system, which partly by means of continuous operation, partly by means of the waste-heat recuperation and utilization as fuel material for the end product constitutes a regulated respectively controlled closed-loop system working in backward flow, which is of self-supplying and having optimal energy requirement.

The object of the invention is a closed-loop continuous operating pyrolysis system for processing rubber waste, comprising pyrolysis furnace provided with dosing tank, and flue-gas channel and external heating unit arranged at its one end to the pyrolysis furnace gas cooler(s) and separating unit(s) known in itself are joined by means of gas collector conduit, while to the other, opposite end of the dosing tank a solid-product sump is joined. The essence of the invention is in that the heat exchanger is arranged between the pyrolysis furnace and the solid-product sump through a gas conduit provided with a gas-meter and a gas-flow control valve and inserting a circulation ventilator and a suction control valve are joined to the outlet gas conduit of the separating unit(s), furthermore consists of a by-pass gas conduit provided with a gas-flow control valve arranged after the circulation ventilator, the by-pass gas conduit is joined to the heating apparatus and the cell cavity of the pyrolysis furnace provided with a temperature detector as well as pressure gauge and/or pressure transmitter, and the latter is connected to the controlling means of the suction control valve.

In a preferred embodiment of the closed-loop pyrolysis system according to the invention the pyrolysis furnace is a rotary-drum furnace, and its heating apparatus is an oil burner.

It is advantageous furthermore, if the liquid outlet of the separating unit is joined to the oil burner.

In a further preferred embodiment the solid-product sump is provided with a sampling unit.

In a preferred embodiment the gas-meter is a measuring orifice.

In a simple embodiment according to the invention the gas coolers are of water-cooled condensers, while their separating units are of gravitational separating units, i.e. sumps having gas-channel outlet and liquid outlet.

In a given case, the separating unit(s) is a cyclone separator or vortex tube known in itself.

In a preferred embodiment according to the invention, due to safety reasons to the closed gas conduits an oxygen and hydrocarbon concentration meter is coupled.

Brief Description of the Drawings

The invention is described in detail with the aid of the enclosed drawing presenting the simple embodiment of the pyrolysis system respectively its operation according to the invention by way of example, in which: on

Figure 1 shows the block diagram of the pyrolysis system, indicating the fundamental controlling means.

Description of the Preferred Embodiments

In the case of the embodiment according to the Fig. 1 the pyrolysis furnace 1 of the pyrolysis system according to the invention is a drum-type furnace of adjustable position, which is provided with a heating apparatus 2 (gas or oil burner) for heating the outer cover and with a flue-gas outlet channel 19.

To the drum-type pyrolysis furnace 1, onto its one end a standing dosing tank 21 is joined. Therein are placed the rubber granules advantageously with the grain size of 1 to 5 mm, which is continuously fed into the reactor chamber of the pyrolysis furnace 1. (The mass flow of the rubber waste can be controlled.)

Onto the other end of the pyrolysis furnace 1 through the heat exchanger 3 is joined the solid-product sump 7. The gas collector conduit 15 joining to the reactor chamber of the pyrolysis furnace 1 serves for the drainage of the hot hydrocarbon gases released during the decomposition of the rubber during the pyrolysis, which (gas collector conduit 15) is well-known in itself and joins to the gas cooler 4, whereto the separating unit 5 is connected. In our example the gas cooler 4 consists of two series connected water-cooled 4a and 4b condensers, to the output of which one separating unit 5a and 5b (simple liquid collecting sump based on the gravity) are connected. The

gas space of the separating unit 5b is connected through the gas conduit 16, by inserting a control valve 8 controlling the exhaustion through a circulation ventilator 6 partly to the heat exchanger 3 partly to the heating apparatus 2 by means of a by-pass gas conduit 18. In the embodiment according to the invention - wherein the heating apparatus 2 of the pyrolysis furnace 1 comprises an oil burner - the liquid space of the separating unit 5a is also joined to the heating apparatus 2. To the gas conduit 17 joining to the heat exchanger 3 a gas-flow control valve as well as a gas-meter 11 (in our example measuring orifice) are joined and the by-pass gas conduit 18 is also provided with a gas-flow control valve 10. To ensure the adjustment (respectively controlling) into the reactor chamber of the pyrolysis furnace 1 a temperature detector 13 and a pressure gauge and/or pressure transmitter 12 are joined, the latter of which is in connection with the actuating unit of the control valve 8; while the solid-product sump 7 is provided with a sampling unit 20. Furthermore, in the Figure is represented the concentration meter 14 joining to the gas conduit 16 as well, by the aid of which the composition of recycle gas compound, especially its O_2, H_2 and CH content (low explosibility limit) can be continuously controlled in order to avoid the explosion risk.

In the figure the connection of the units are represented by full line, the direction of the material flow is shown by arrow, while the connection of the detecting elements and actuating units for controlling respectively adjusting tasks is represented by dash line.

The operation respectively working principle of the pyrolysis system can be followed on the basis of the Figure. Bringing into service the closed system has to be filled with inert gas of air pressure, expediently with CO_2 gas or with inert gas of high CO_2 content, then by means of operating the circulation ventilator 6 the pressure is adjusted to the value of $\Delta p = 0 - (-30)$ water column mm less than the atmospheric pressure. The mild suction ensures - as the air-consistency of the system cannot be ensured in the practice, respectively difficult to realize - that the pyrolysis product should not get to the environment, preventing the contamination of the environment respectively the material loss, and at the same time, the entering air respectively its O_2 content is negligibly small and does not disturb the process of the pyrolysis.

The circulation ventilator 6 continuously circulates the recirculated inert gas in counterflow with the fed rubber grinds, the quantity of which during the process increasingly extends and dresses (as a result of the pyrolysis process). The by-pass gas conduit 18 provided with gas-flow control valve 10 and joining to the heating apparatus 2

serves for drainage of the spare gas quantity, respectively for utilization of its inflammable CH content.

The extent of the decomposition of the rubber waste, the quantitative proportions of the solid- and liquid products respectively their composition - naturally in the function of the fed initial reactant - depend fundamentally on the conditions of the pyrolysis taking place in the pyrolysis furnace 1, which is determined in addition to its temperature T, by the contact time of the rubber waste respectively its contact time with the counterflow gas (the time spent together). (Naturally it can be influenced by catalytic agent). Its coordinated adjustment (respectively controlling) is ensured by the detectors fitted into the system respectively by the controlling means, furthermore by the formation of the drum-type pyrolysis furnace 1.

The composition of the generated solid product is checked by the sampling unit 20 joining to the solid-product sump 7. The content of its volatile component is extremely characteristic to the extent of the decomposition. (Should the content of the volatile component is ≤1%, the decomposition of the carbon compound can be considered practically complete.) Depending on the result of the sampling there is a possibility for controlling the temperature of the pyrolysis furnace 1. By increasing the temperature the liquid-product yield increases, more exactly, the hydrocarbon content of the hot gas developing in the pyrolysis furnace 1, and there is a possibility to control the stay-together period, the latter can be influenced e.g. by the feeding rate of the rubber grinds as well as controlling the gas flow speed and the gas flow quantity. The latter is made possible by the gas-meter 11 inserted into the gas conduit 17 as well as by the gas flow control valves 9 and 10, by means of which the gas quantity being in the gas conduits 17 and 18 as well as the rate of the gas quantity can be adjusted, in the function of the measured value.

The dwell time of the solid material (rubber grids) in the pyrolysis furnace 1 takes about 10 to 120 minutes, the dwell time of the gas phase takes 1 to 10 sec depending on the required composition of the generated products.

From the pyrolysis furnace 1 through the gas collector conduit 15 the exiting gas is of 400 to 600 °C temperature, which will be cooled by means of conducting to the separating unit (in our example into the gas coolers 4a and 4b respectively into the separating units 5a and 5b) and the so condensed liquid product - in our example in two fractions - is separated from the gas. The composition and the quantity of the liquid

product depend on the feedstock and essentially on the conditions of the pyrolysis. Its quantity considering the feedstock is of 40 to 55 weight percent, while considering its composition, it can be considered light fuel, which is of natural oil type, rich in olefins and suitable for direct utilization or further processing. The most essential feature of this liquid phase is in that - contrary to the natural oils - its sulfur content is very low, i.e. 0,6 to 0,8 percent. It is about the 1/3 of the sulfur content of the feedstock, while the further part of 2/3 accumulate in the solid product (coke), the gas phase of small quantity contains only slight sulfur compound, so the flue gas can be exited direct to the free.

The recooled gas (the mixture of the inert gas and the generated CH gas) passing through the heat exchanger 3 contacts with the hot coke coming out of the pyrolysis furnace 1, and cooling it down considerably pre-heats itself. By this pre-heating the heating energy requirement of the system can be reduced by about 20-30 percent.

The comburent content of the gas mixture enriched by hydrocarbon amounts to about 5-15 percent, which passing through the gas conduit 18 into the heating apparatus 2 will be utilized. By means of burning of the hydrocarbon comprising in the redundant gas - depending on the condition of the pyrolysis - the 40 to 60 percent of the heat energy requirement can be ensured.

The further required heat energy is ensured by burning about the 10 to 25 percent of the liquid product separated in the separating unit.

Accordingly, the closed-loop continuously operating pyrolysis system according to the invention generates itself the energy required for its operation, meanwhile produces re-utilizable, environment protecting end-product from the cheap, waste basic components, and the resultant by-products neither load nor pollute the environment.